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BREAKDOWN OF SOFTWARE EXPENDITURES
IN THE DEPARTMENT OF DEFENSE,
UNITED STATES AND IN THE WORLD

by

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September, 1991

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IN THE DEPARTMENT OF DEFENSE,
UNITED STATES, AND IN THE WORLD

by

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ABSTRACT

This study was conducted to identify credible sources for estimating expenditures in software development, maintenance, and acquisition. This research encompasses the United States, the Department of Defense and the world.

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I. INTRODUCTION

The software industry is one of the fastest growing industries in the United States. With large expenditures on software each year, it is of interest to know where the money is being spent, and what the trends are. This study identifies credible sources of software expenditure estimates, but more significantly, identifies software expenditure estimates for the U.S., Department of Defense (DOD) and the world.

The figures presented in this study were derived from various sources, often with inconsistent definitions and classifications. The research revealed that there is no single source that identifies software development and maintenance costs. Companies who develop their own software do not separately report software expenditures. Identifying these costs is rather a process of detection, extrapolation of figures from diverse sources, and a synthesis that provides a reasonable estimate of these costs.

A second difficulty is that, in the U.S. and DOD, a large proportion of software is embedded. Software embedded in computer systems can be found almost everywhere. For example, software is embedded in household appliances, automobiles and automatic teller machines. Again, there is no mechanism for

reporting what proportion of a product's cost represents the embedded software.

A third difficulty is that there are no consistent definitions or methods of classifying software. This has led to software expenditures being combined with hardware, services costs, or even excluded from reports. And lastly, with the software industry expanding, many of the small private businesses are not included in surveys, giving an inaccurate account of software expenditures.

Table 1 defines the categories for identifying expenditures and revenues in this study. Organizations obtain software from three sources: packaged software purchased off-the-shelf, contract for a custom designed system, or they write their own software in-house. The first two sources can be estimated from publicly available figures because they represent reported sales of software or services. In-house expenditures are rarely reported and certainly not reported at an industry level, therefore, in-house must be estimated. While these three categories apply to information technology systems in the DOD, expenditures for embedded software are estimated separately.

TABLE 1 U.S., DOD, AND WORLDWIDE EXPENDITURE CATEGORIES

Software developed in-house.
Packaged software - commercially developed, off-the-shelf.
Professional Services - contract programming, design, software developed for a specific system.

Packaged software is becoming increasingly important at the expense of in-house development. In 1980, in-house development was almost one-half of the software expenditures, while packaged software was one-fifth. By 1990, in-house development had dropped to one-third and software products increased to almost one-half. The same breakdown applies to DOD's automated information systems (AIS), however, most of the software developed for the DOD is embedded, which is not reported and has to be estimated. Figure 1 represents the decrease in software being developed in-house and increase in software purchased off-the-shelf over the last decade within the U.S. (Sayadian, 1990 and author's in-house development estimate).

U.S. SOFTWARE AND SERVICES PERCENTAGES for 1980 and 1990

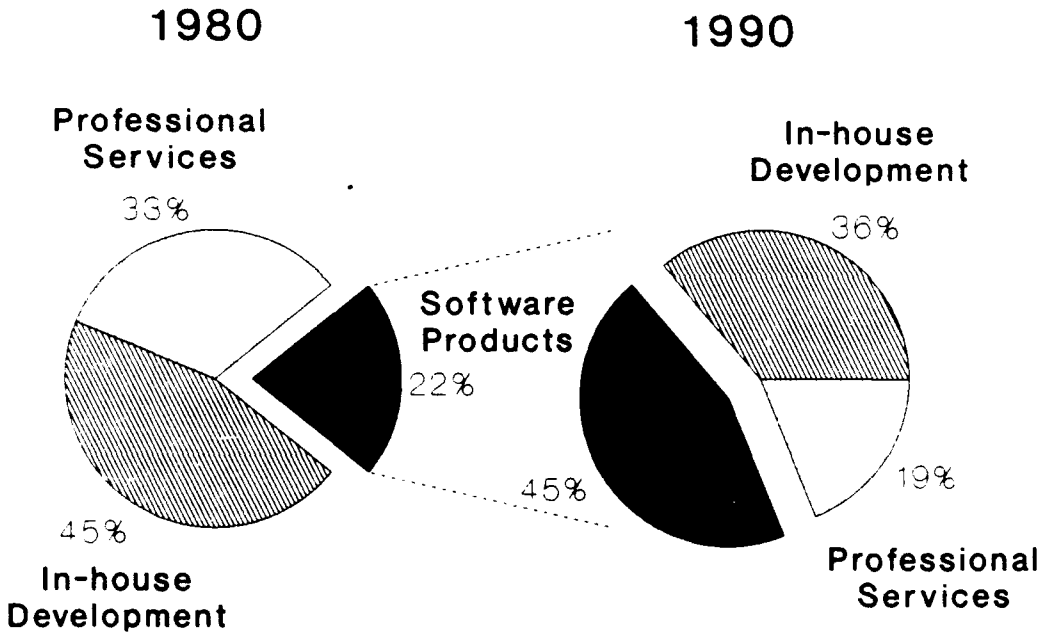


FIGURE 1

This study consists of six chapters and two appendices. Chapter I contains introductory material. Chapter II, Prior Research, reviews other researcher's estimates of software expenditures. An explanation of where their numbers came from is also given. Chapter III covers the U.S. domestic revenues of the software market. Identified in Chapter IV are the DOD sources for software expenditures. Chapter V provides worldwide software and services expenditures. Specific areas for further research and limitations found during this study are identified in Chapter VI. The conclusions are provided in Chapter VII. Appendix A is a description of the sources used in this study, and Appendix B contains a copy of the DOD's Exhibit 43A for Fiscal Years 1992 and 1993 Report on Information Technology Resources.

II. PRIOR RESEARCH

This chapter provides previously published software expenditure estimates for the U.S., DOD and the world. The table, provided at the end of the chapter, includes these sources, and identifies their estimates.

Initial research established that individual organizations, government agencies, and market research firms do collect software development and maintenance expenditures data, however, this information is often combined with other related software expenditures. These combined costs can include as many separate elements as: purchase and lease of software expenditures, hardware purchases, commercial services, professional services and personnel compensation.

The sources selected for this study were obtained from government agencies, private research firms and computer industry publications. These sources were broadly consistent with each other but tended to differ in their definitions and breakdowns of each category. Additionally, these sources tend to rely on each other for part of their information. Specific breakdowns into software development and maintenance were not always available. Acquisition, or market revenues, were easier to identify.

The Mitre Corporation, *Datamation* and International Data Corporation (IDC) gather their information by the use of

surveys and information already publicly available. Surveys represent a financial snapshot of the industry at a critical juncture. These surveys can be industry wide, worldwide, or limited to a smaller sector. *Datamation's* "The Datamation 100" (Kelly, 1990), is an example of a worldwide survey that limits its study to the world's 100 largest information technology suppliers.

The Mitre Corporation (Mitre) conducted a survey of the software industry in 1989 which encompassed both the private sector and DOD (Vasilik, et al. 1990). The Mitre survey calculated total software revenue for the U.S. by adding up the revenues for each type of software according to how they were sold. *Datamation* also conducts smaller scale surveys throughout the year on U.S. based organizations that reflect both hardware and software expenditures, revenues and trends.

IDC surveys 30 countries around the world to obtain a profile of information technology spending each year. Responses are collated, market sizing and forecasts are coordinated and verified through the regional research centers. Questions are resolved through the headquarters, in Framingham, Massachusetts, and compared to demographic and economic metrics. These figures are broken into categories: hardware, packaged software, data communications, and services (support and professional). (Bellomy, 1990)

The U.S. Department of Commerce obtains some of its information from other government agencies, but most comes

from private research firms and periodicals, for instance, IDC and *Datamation*. The Computer and Business Equipment Manufacturers Association (CBEMA) gathers much of its U.S. and world data from member companies that encompass about half of the information technology industry's revenues and market research firms (Sayadian, 1990). For example, CBEMA's Industry Marketing Statistics Committee in cooperation with BDA Associates, Inc. based its data on proprietary industry data collected from the U.S. government and financial data from publicly available sources. A common theme within all sources is that the estimations and projections they provide may not be consistent with each other since these techniques and data bases vary.

There are no comprehensive systems in place today to capture and calculate development and maintenance costs. Each organization establishes its own ground rules to ascertain how each cost will be accounted for. Consideration must also be given on how to differentiate hardware and software costs when a project is canceled before completion. (Park, telephone conversation, 1991)

The scarcity of accurate data is evident from the many inconsistencies found among different sources. The principal difficulties regarding statistics about the software industry are:

- Inconsistent definitions or classifications: each organization has its own definition of what encompasses software expenditures.
- No standardized way to track costs.
- Software costs are hidden (lumped with hardware and services, or excluded from budgeting reports); not specifically identified; not reported; and difficult to identify.
- Very costly and time-consuming to collect the data.
- No one organization is specifically collecting software development and maintenance data.
- Survey instruments that are used to obtain data: may be filled out carelessly, may be misinterpreted by the respondent or by the analyst, data processing errors may occur in the course of forming or processing a data base of industry statistics.

Table 2 is a summary of sources and their software expenditure estimates. Diverse and conflicting software expenditures for the DOD, U.S. and the world from 1973 to 1990 have been published. A comparison of the figures reveals the type of inconsistencies that make it difficult to determine a clear picture of what is being spent to create and maintain the myriad computer programs in use today. It is probable that only Dr. Boehm's estimates in 1985 and Mitre's 1988 - 1990 estimates include software developed in-house. That may account for the inconsistency in figures given by the U.S.

Department of Commerce and IDC who report sales revenue. It is impossible to determine whether expenditures for software developed in-house, for internal use, has been included. More often than not, the figures only include market revenues.

The 1988 and 1989 IDC and Department of Commerce figures seem implausibly low. In both 1988 and 1989, IDC figures of $22 billion for the U.S. and a little over double that for the world seem improbably low.

The U.S. Department of Commerce's *U.S. Industrial Outlook 1989*, based in turn on IDC figures, states that the worldwide software market grew to an estimated $55 billion in 1988. It is certain the figure represents only revenue and does not include in-house development.

Two IDC reports provide packaged software and professional services expenditures for the U.S. and the world. Software developed in-house is not accounted for. IDC accounts for other revenues in its professional services, like hardware maintenance, which has to be deducted for the purpose of this study. The same 18.4 percentage estimate was used for the U.S. in 1989 and also in 1988. (Bellomy, 1990 and Moschella, 1989)

TABLE 2 SUMMARY OF SOFTWARE EXPENDITURES AND REVENUES
(in billions)

YEAR	DOD	U.S.	WORLD	SOURCE, METHOD, COMMENTS
1990	31	128		Mitre, forecast from 1989 survey, DOD - $10 B purchased software, $21 B embedded; U.S. $128 B estimate - 13% growth rate of $117 B in 1989
1989		117		Mitre, forecast from 1989 survey, $8 B govt direct purchases, $11 B U.S. exports, $94 B U.S. software expenditures, $3.6 B PC software purchases (Business Week, 1989)
1989		24		U.S. Dept of Commerce, U.S. Industrial Outlook - 1990, domestic revenues only
1989		22	53	IDC, 1990 survey, U.S. - $15.8 B packaged software and $6 B professional services (sw development/maintenance) revenues only; world $36.7 packaged software, $16 B professional services revenue only
1988		22	46	IDC, 1989 survey, U.S. - $16.7 B packaged software and $5 B professional service revenues only; world $32.5 packaged software, $13.1 B professional service revenue only
1988			55	U.S. Dept of Commerce, U.S. Industrial Outlook - 1989 worldwide software market revenues; U.S. firms furnish 60% of world software
1988	26	100		Mitre, 1989 survey - DOD about 10% of total DOD budget. Estimate of U.S. is software revenue which includes DOD expenditures
1985	11	70	140	Dr. Barry Boehm 1987 estimate - states maintenance 70% of software costs
1978		20		Phister's aggregate information system spending data (Phister, 1979)
1976	3			DepAsst SecDef, Materiel Acquisition, - 68% development cost, 32% maintenance
1974	3			GAO report to OSD March 1989 in review of Ada implementation
1973	3	20		Dr. Boehm, U.S. - 2/3's spent on maintenance, DOD approx - 30% business DP, 25% scientific, 35% embedded software

Table 2 shows that software, no matter which way it is classified or categorized, has grown over the past 20 years. The table reflects the variety of ways software has been reported.

The DOD software costs were estimated at $11 billion in 1985 (Boehm, 1987). These DOD figures were derived from the Office of the Secretary of Defense's analysis of software costs in 1980 and by multiplying by the annual growth rate of 12 percent to obtain the $11 billion estimate (Boehm, telephone conversation, 1990).

The U.S. software costs were estimated at roughly $70 billion in 1985 (Boehm, 1987). The U.S. figure was established from Dr. Boehm's indepth analysis of various segments of the software market and using the Bureau of Labor Statistics (BLS) employment statistics. He took into account people with data processing job descriptions and people in jobs that do not specifically have development titles but yet spend all day, or a portion of the work day programming or are involved in development. Additionally, a sample analysis of representative industry organizations was conducted to compare his analysis. (Boehm, telephone conversation, 1990)

Estimated worldwide software spending was roughly $140 billion in 1985 (Boehm, 1987). The worldwide figure was an estimate based on the U.S. accounting for half the world market at that time (Boehm, telephone conversation, 1990).

The Mitre Corporation's survey of the industry and government was conducted in 1989 (Zraket, et al. 1990). The survey calculated total software revenue for the U.S. by adding up the revenues for each of the categories of software according to how they were sold, for example: packaged (commercial software), custom (developed for specific use), embedded (machine or weapon system), and other (special function software).

In 1990, Mitre estimated the DOD spent approximately $31 billion for software. Approximately $10 billion was spent on the purchase of software for administrative systems. An estimate of approximately $21 billion was spent on embedded software. (Zraket, et. al. 1990)

In summary, we find that there is no consistent manner in which to report the three categories: packaged software, professional services and in-house development. A wide variety of figures have been published without consistencies or industry standards. There is a broad general agreement on trends, however, some sources give widely differing values since they are using different definitions of what is included in total software expenditures. Where accurate numbers are not available, the tendency of various sources to cite each other may reinforce inaccurate estimates. This study, in the following chapters, strives to go beyond these limitations and provide reasonable software expenditure estimates.

III. UNITED STATES

A. INTRODUCTION

Historically, the U.S. has been by far the largest user of computers and still maintains the largest market share of hardware and software, accounting for approximately half of the worldwide revenues. This chapter identifies the U.S. software expenditures over the last few years and highlights trends.

In 1980, 550,000 software specialists produced $13 billion worth of software in the U.S. By 1990, $90 billion worth of software was generated by 1.2 million software specialists. In this decade, the proportion of the software produced in-house, by its users, dropped from 58 percent to 38 percent.

B. ESTIMATION OF SOFTWARE EXPENDITURES

Software expenditures consist of purchases of packaged software and professional services, which include contract programming and in-house software development. This study has found that most published sources on software expenditures do not include in-house expenditures and these have had to be estimated.

Table 3 is an excerpt from CBEMA's *Information Technology Industry Databook 1960-2000* (Sayadian, 1990). Domestic software and services expenditures are given in constant

(1990) dollars. These software figures encompass general purpose and embedded software. CBEMA's figures also include processing services and do not include in-house development. Processing services is defined as consisting of complete processing and preparation of reports from data supplied by the customer or may be a special service such as key punching or timesharing of data processing equipment. In this study, processing services is not considered as a software expenditure.

TABLE 3 CBEMA DOMESTIC SOFTWARE AND SERVICES EXPENDITURES (in billions)

Year	Total	Processing Services	Software Products	Professional Services
1980	18.00	10.80	2.85	4.35
1981	21.00	11.55	3.95	5.50
1982	23.50	12.65	4.90	5.95
1983	28.20	14.40	6.90	6.90
1984	35.25	17.15	10.00	8.10
1985	40.70	19.31	12.12	9.27
1986	45.00	20.75	14.15	10.10
1987	53.85	23.60	18.50	11.75
1988	68.05	26.90	27.85	13.30
1989[E]	79.84	30.13	34.81	14.90
1990[E]	92.36	35.00	40.36	17.00

Source: Computers and Business Equipment Manufacturers Association

[E] - Estimate

Table 4 represents Computer and Data Processing Services industry, systems analyst and programmer employment from 1980 to 1990 (Sayadian, 1990). The number of programmers and analysts producing in-house software were obtained by subtracting the systems analysts and programmers from the computer and software industry number for each year. The estimated yearly expenditure per programmer is calculated by taking the software industry revenue, subtracting processing services, and dividing by the number of systems analysts and programmers in the software industry.

In-house software expenditures per software professional were estimated to be $73,822 per software professional in 1990. This equates to approximately $33 billion being spent in 1990 on software developed internally. This may overestimate the productivity of programmers because each of their products is used only once. These figures exclude non-computer professionals working on their PC's, developing software produced by end-user computing or personal computing. Also note that this agrees with the rule of thumb of $1 overhead for each dollar of programmer compensation. Additionally, industry revenues include exports but exclude imports. However, the two figures have historically almost been equal so revenues are an excellent surrogate for expenditures.

TABLE 4 SYSTEMS ANALYST, PROGRAMMER, AND IN-HOUSE EMPLOYMENT (in thousands)

Year	Systems Analyst	Program-mers	Analyst Prog'mr Total	Data Proc'g Industry	In-house	Annual Expenditure per Prog'mr
1980	205	351	556	304.3	251.7	23,660
1981	213	367	580	336.6	243.4	28,075
1982	242	434	676	364.7	311.3	29,750
1983	276	443	719	415.9	303.1	33,181
1984	310	507	817	475.1	341.9	38,097
1985	359	534	893	542.4	350.6	39,436
1986	385	549	934	589.4	344.6	41,144
1987	447	527	974	630.5	343.5	47,978
1988	479	570	1049	678.4	370.6	60,657
1989[E]	513	617	1130	728.0	402.0	68,283
1990[E]	550	668	1218	777.0	441.0	73,822

Source: Computers and Business Equipment Manufacturers Association

[E] - Estimate

Table 5 shows software expenditures for the U.S. CBEMA's processing services are subtracted from the software revenues (in Table 3) and in-house estimates are added. In-house expenditures were estimated by taking the number of programmers and analysts employed each year and subtracting those employed in the computer and data processing industry, leaving the number of people working developing software in-house (see Table 4 for employment statistics). In-house software expenditures are then estimated by multiplying the number of in-house software professionals by an estimated

expenditure per professional. For example, in 1985, 350,000 programmers and analysts, at an estimated expenditure of $40,000 each, produced approximately $14 billion worth of software in-house.

TABLE 5 U.S. SOFTWARE EXPENDITURES
(in billions)

Year	Software Revenue Total	**MINUS** Processing Services	**PLUS** In-house* Development	**EQUALS** Software Expenditures
1980	18.00	10.80	6.00	13.20
1981	21.00	11.55	6.83	16.28
1982	23.50	12.65	9.30	20.15
1983	28.20	14.40	10.10	23.90
1984	35.25	17.15	13.02	31.12
1985	40.70	19.31	13.83	35.22
1986	45.00	20.75	14.20	38.45
1987	53.85	23.60	16.50	46.75
1988	68.05	26.90	22.50	63.65
1989E	79.84	30.13	27.44	77.15
1990E	92.36	35.00	32.60	89.96

Source: Computers and Business Equipment Manufacturers Association and author of this study

* - Computed as programmer/analysts developing software in-house multiplied by estimated annual expenditures per programmer/analyst

E - Estimate

Table 6 shows the worldwide revenue of U.S. Computer and Business Equipment industry in 1990 was estimated to be $284 billion, of which approximately $90 billion, or 31.6 percent

was for software. In contrast, 1980 total revenue was $90 billion, and only 15.2 percent, or $13 billion, was for software. (Sayadian, 1990)

TABLE 6 COMPUTER AND BUSINESS EQUIPMENT INDUSTRY WORLDWIDE REVENUE (in billions)

Year	Total Revenue	Software Total[C]	Hardware Total
1980	86.37	13.20	73.17
1981	97.80	16.28	81.52
1982	110.81	20.15	90.66
1983	127.25	23.90	103.35
1984	150.19	31.12	119.07
1985	165.64	35.22	130.42
1986	177.10	38.45	138.65
1987	198.28	46.75	151.53
1988	230.93	63.65	167.28
1989[E]	257.15	77.15	180.00
1990[E]	284.32	89.96	194.36

SOURCE: Computers and Business Equipment Manufacturers Association
[C] - Calculation; software products, professional services and in-house development estimate
[E] - Estimate

Figure 2 shows that in 1980, software was one-sixth of the total Computer and Business Equipment industry worldwide revenues. By 1990, software's proportion had increased to almost one-third. Figure 3 shows how software revenues have grown over the decade and that the distribution has changed. In 1980, in-house development's proportion was 45 percent of the software expenditures, while professional services were 33

percent, and sales of software products were 22 percent. By 1990, in-house development had decreased to only 36 percent, and professional services decreased to 19 percent. Sales of software products had increased to 45 percent.

U.S. TOTAL INDUSTRY REVENUE WITH SOFTWARE EXPENDITURES

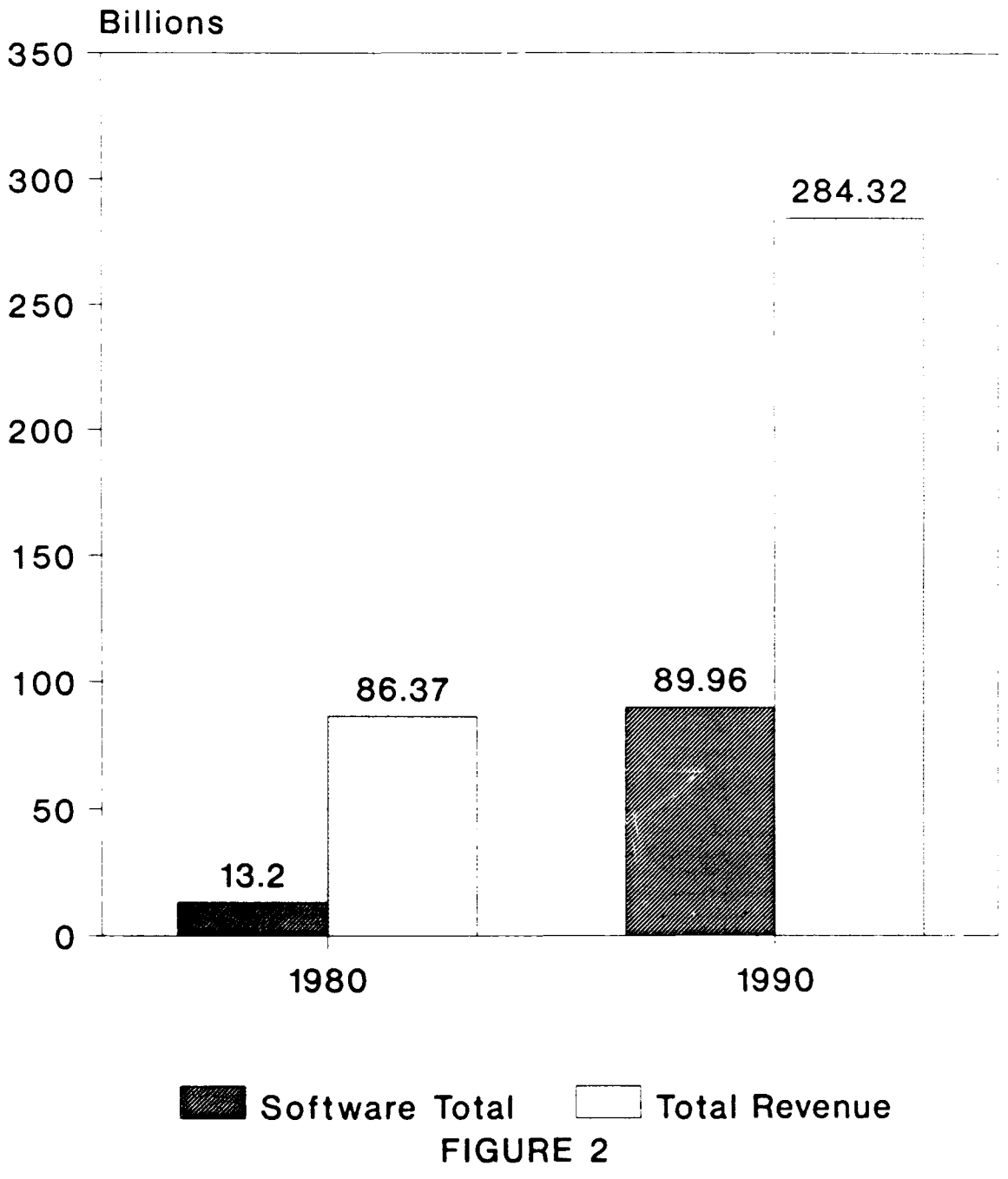


FIGURE 2

U.S. SOFTWARE REVENUE

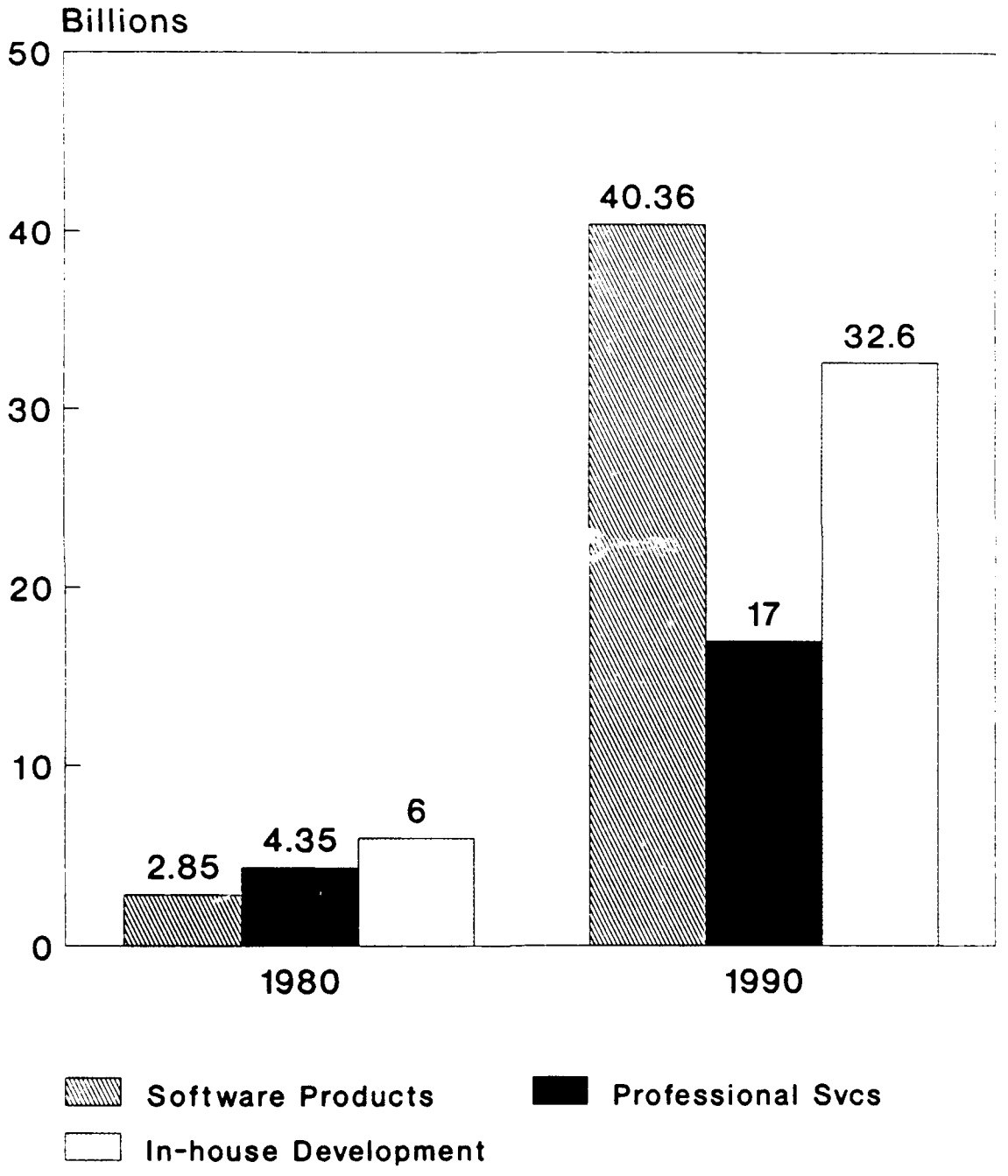


FIGURE 3

C. THE MITRE STUDY

The Mitre Corporation provides an extensive overview of software expenditures in relation to the software industry, and software usage throughout the private sector and DOD. Mitre's software industry survey (Zraket, et. al. 1990), conducted in 1989 identified 1988 U.S. and DOD software expenditures. Verification of its estimates has not been validated as this independent study defines its categories differently. However, the survey's estimates increase the range of confidence of the author's estimates presented in this study. Although Mitre's numbers are different from other sources, they provide an interesting set of breakdowns of embedded software expenditures that no other source provides.

The survey, from which the estimates were derived, studied 47 secondary organizations. Much of its information on the structure of the software industry came from the Massachusetts Computer Software Council (MCSC). The survey by MCSC covered some 800 companies; 44 percent of those employed fewer than 10 people. Other major sources included: Federal Sources, Inc., Air Force Systems Command, Defense Marketing Services, Defense Sciences Board, National Software Association and the Software Engineering Institute.

The Mitre Corporation estimated approximately $128 billion in revenue for the U.S. in 1990. This incorporates both civil and DOD figures. Packaged software generated about $33 billion, as did custom software. Embedded software was

approximately $42 billion while another $20 billion of revenue was earned for other software packages like entertainment, education and telecommunications.

Table 7 shows the survey results. The 13 percent growth rate was used to estimate 1990 figures. Estimates of the U.S. software effort was valued at some $100 billion in 1988, of which $26 billion represented DOD expenditures for software. In 1990, the U.S. effort was estimated to be approximately $128 billion, with the DOD contributing over $33 billion.

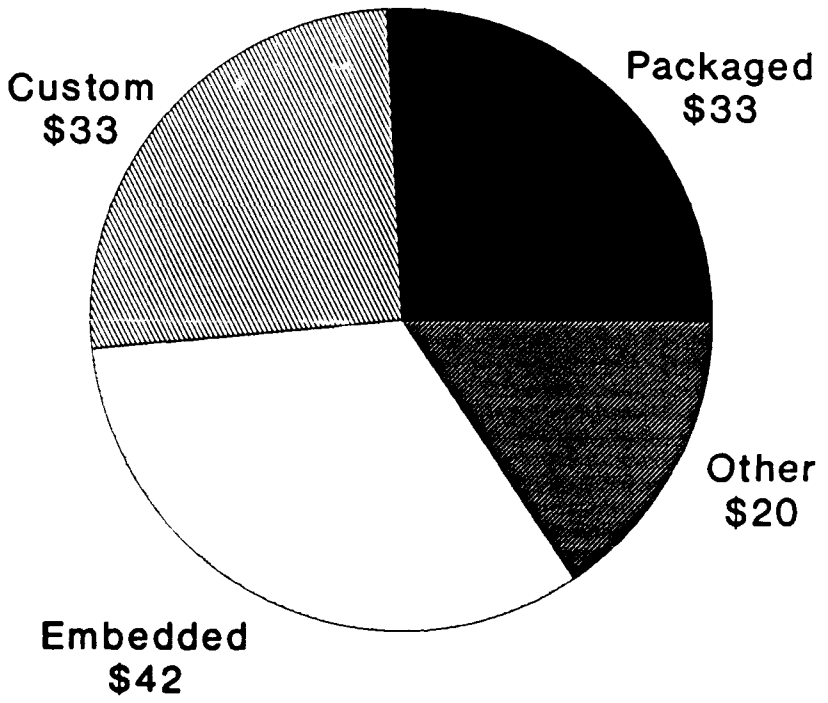
TABLE 7 MITRE CORPORATION ESTIMATE OF U.S. SOFTWARE REVENUE
(in billions)

	1988	1990[E]
Packaged	$26	$33.2
Software companies	10	12.8
IBM	8	10.2
Other Hardware Companies	8	10.2
Custom	$26	$33.2
DOD	8	10.2
Civil	18	23
Embedded	$33	$42.1
DOD	18	23
Civil	15	19.1
Other	$15	$19.2
(Entertainment, education, telecommunications, etc)		
TOTAL	$100	$128

Source: Mitre Corporation
[E] - Estimate

Figure 4 graphically represents Mitre's 1990 estimation for each category based on 13 percent growth rate. The packaged, custom, and embedded estimates are similar to CBEMA's estimates. However, Mitre uses different category definitions, which make it difficult to compare and validate the figures.

U.S. SOFTWARE SALES/EXPENDITURES
1990
(in billions)



Total: $128 billion

FIGURE 4

D. PACKAGED SOFTWARE

Table 8 is a breakdown of packaged software revenues for 1990 (Curran, 1990). Sales are broken into application programs, tools and system utilities, totaling $30 billion. This total appears to exclude some or all of Mitre's "Other" category. It is interesting to note that even though there is a lot of research in the artificial intelligence (AI) field, it is still a small percentage of the software market.

TABLE 8 SOFTWARE MARKET REVENUES
(in millions)

	1988	1989	1990
Application Programs (word processing, accounting, etc)	5,720	6,808	8,169
Application Tools, total	4,371	5,090	6,218
Databases	2,350	2,770	3,517
CAD/CAE/CAM	1,365	1,480	1,658
Desktop publishing	533	650	790
Artificial Intelligence	55	90	126
Image processing	68	100	127
System Utilities (operating systems, debugging, diagnostic tools)	10,346	12,830	15,396
CASE Tools	161	214	270
Software, total	20,598	24,942	30,053

Source: Electronics Magazine

Figure 5 graphically shows a steady increase in all categories. Percentage-wise, each category maintains its growth with nearly the same market share throughout the three years presented.

U.S. SOFTWARE MARKET REVENUE

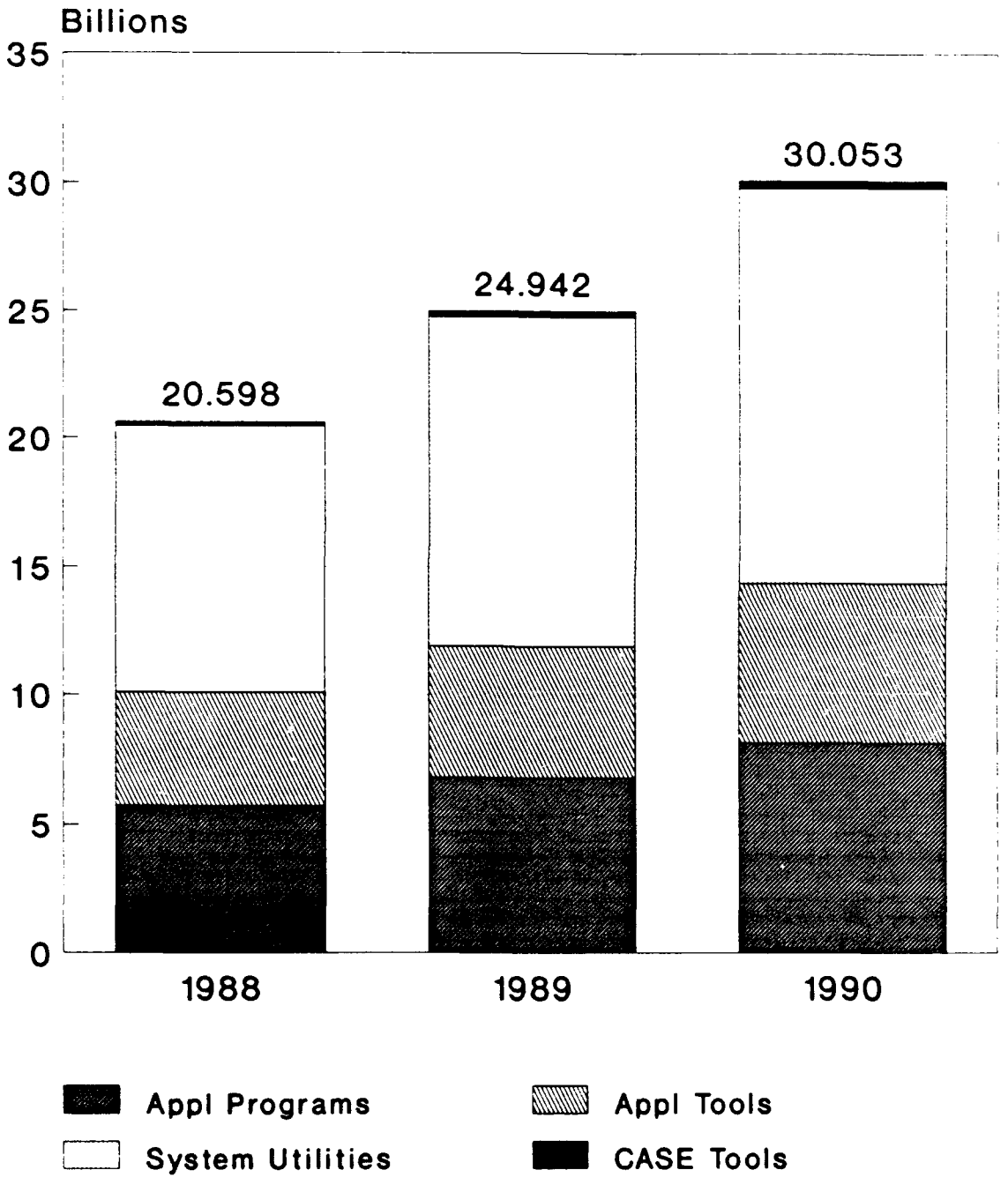


FIGURE 5

E. TRENDS

The 1990 software industry is currently a $90 billion industry in the U.S. "The software and services sector has grown at an average annual rate of 18 percent since 1980. It has been the fastest growing sector of the computer and business equipment industry. The forecast for this sector is to grow at an average annual rate of 12.7 percent, increasing to $297.7 billion by 2000." (Sayadian, 1990)

Factors that slowed industry growth in 1989 include consolidation activity, development backlogs, the continuing move toward open systems and foreign software development (Juliussen and Juliussen, 1990). Although the U.S. software industry continued to lead the world in technology and sales in 1989, competition from foreign software suppliers increased. Because of the strategic and economic potential of new software, many foreign countries began to focus on developing their software industries. (U.S. Department of Commerce, 1990)

Over the last decade, the increasing importance of software as compared to hardware, and the increasing importance of purchased software compared to in-house development has contributed to the steady and rapid growth of the software industry.

Figure 6 graphically represents the domestic software and services expenditures for 1980, 1990 and projects year 2000 figures. Both in-house development and professional services

proportions are decreasing substantially over this 20 year period while software product sales have increased. The projection for 2000 is based on a 12.7 percent average annual growth rate. (Sayadian, 1990)

SOFTWARE AND SERVICES EXPENDITURES
1980 - 2000 (Projections)
Source: CBEMA

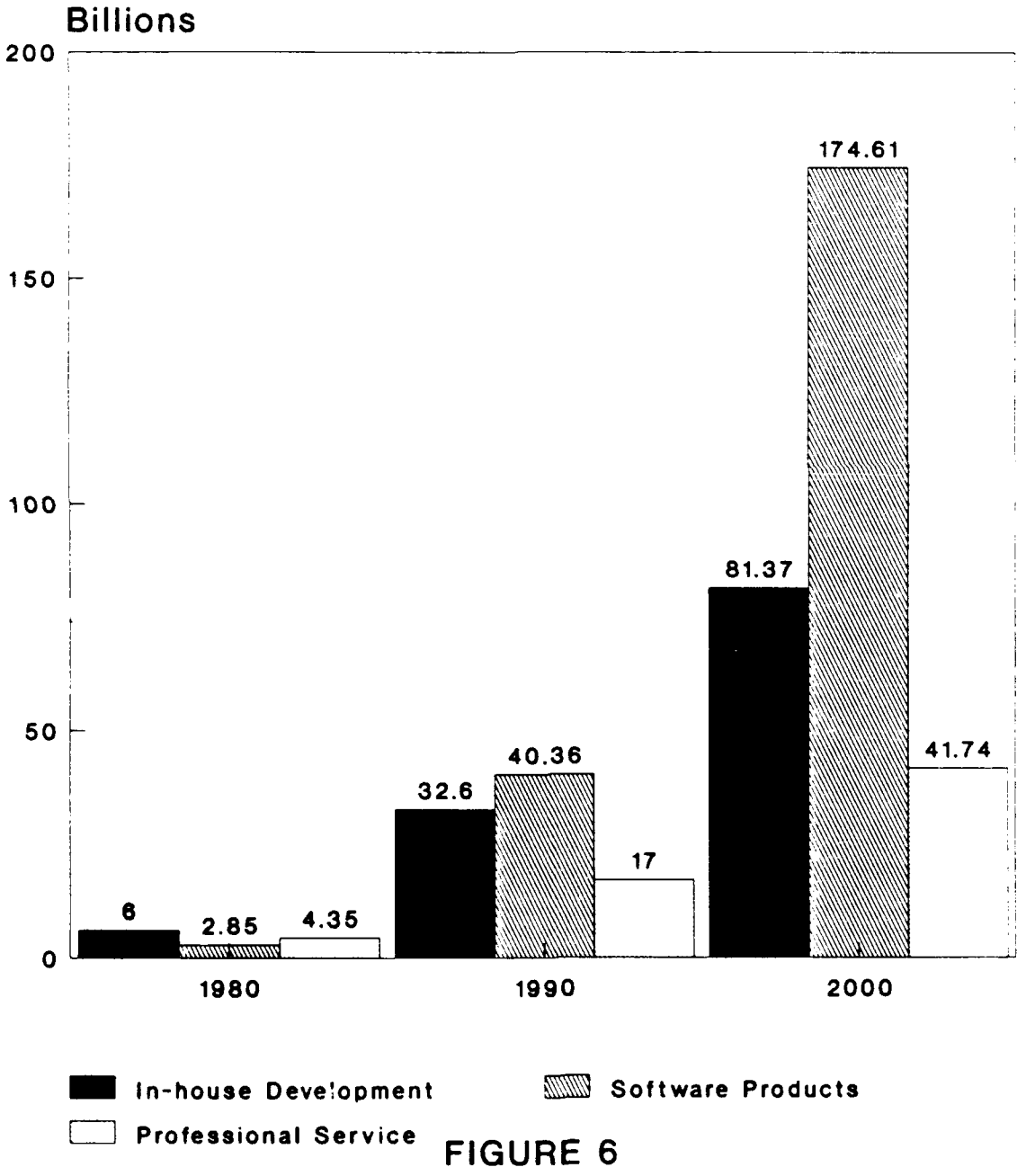


FIGURE 6

Projections for this decade see an increase in Computer Aided Software Engineering (CASE) technology and use. CASE is becoming very important because it improves the productivity of computer programmers. Office automation will steadily increase by automating many common tasks such as writing, calculating, filing, drawing, managing, decision making and communicating with others. Both the educational and recreational ("other" category) software market will continue to grow as the large home PC market continues to grow. (Juliussen and Juliussen, 1990)

Both the U.S. government and the private sector continue to show interest in artificial intelligence. Progress in the development of advanced AI systems is projected to result in the development of highly sophisticated software and hardware products. For instance, the combination of neural network technology and expert systems applications is hoped to bring about neural network software programs and neurocomputers capable of solving complex tasks at faster computational speeds. During the 1990's, AI technology is projected to become an embedded function merging with mainstream computer systems. Increasingly, companies will need these systems to maintain their competitive edge. (U.S. Department of Commerce, 1990)

IV. DEPARTMENT OF DEFENSE

A. INTRODUCTION

Historically, the Department of Defense has been the largest user of computers and software in the nation. Estimated 1990 expenditures by the DOD for software development and maintenance were $27 billion. This includes approximately $4 billion for administrative software and an estimate of $23 billion for embedded computer software.

It is interesting to note that DOD software expenditures are usually cited as being $30 billion per year (Deputy Secretary of Defense, 1985; Defense Science Board, 1987; U.S. General Accounting Office, 1990; Sally Brown, telephone conversation, 1991), however, there is reason to suspect these agencies and people are sharing the same quote. Dr. Boehm, estimated that the DOD was spending about $28 billion in 1990 (Boehm, telephone conversation, 1990). A recent article in the *Federal Computer Week* stated, "Mr. Paul Strassmann, the director of Defense information, might control as much as $30 billion spent annually by the Pentagon for command, control, communications, computers and intelligence systems" (Green, 1991).

The Department of Defense software expenditures are only an estimate, since complete, detailed figures are not readily available. Part of the reason for this is that DOD software

purchases fall into two accounting categories. Those involving administrative functions, such as automated information systems (AIS), personnel management and accounting and finance, are governed by the Brooks Act, which controls government-wide procurement of computer systems and software and requires reporting to the Congress (U.S. Office of Management and Budget, November, 1990).

The second category is embedded software is used for military functions, such as command and control, intelligence, and weapon systems; and is exempt from Brooks Act procedures and software expenditures are not required to be tracked. Research and development are also exempt. Estimates given for embedded software are gathered during interviews of DOD officials and through inspections. Two different agencies are responsible for these two categories. (U.S. General Accounting Office, 1990)

B. AUTOMATED INFORMATION SYSTEMS

Placing administrative software expenditures in perspective, the overall total of DOD expenditures for fiscal year 1990 was $289.8 billion (U.S. Department of Treasury, 1990). Of that, $8.7 billion was budgeted for DOD's information technology systems excluding software embedded in weapon systems and deductions for inter and intra-agency service deductions. Approximately $3.7 billion of this was spent for software: purchase and lease of software, personnel compensation, supplies, operations and maintenance, systems

analysis, programming, design and engineering. Hardware costs were approximately $3.9 billion and include purchases and leases, voice communications, data communications, hardware's portion of operations and maintenance and personnel compensation. About $554 million was allocated to operations and management overhead accounted for approximately $486 million. (U.S. Department of Defense, Exhibit 43A, 1991)

The figures reported in the aggregate are reasonably consistent, however, there are possible misreported categories due to individual service interpretation. A definition problem exists. What and how a system is defined for reporting purposes is not clear and each service sets their own definition. (Beyer, telephone conversation, May 1991)

The DOD is required by law to submit Exhibit 43A (summary of IT systems cost by the DOD) to the U.S. Office of Management and Budget (OMB) for each major AIS. However, the Exhibit 43A limits the ability to distinguish overall software costs as these expenditures are grouped under capital investments and commercial services. (U.S. Office of Management and Budget, Circular No. A-11, 1990)

Operations and Maintenance, under Commercial Services, is the expenditure for contracts to provide services associated with the operations of existing systems. This includes both hardware and software maintenance. The DOD is unable to determine what percentage is software related. Systems analysis, programming, design and engineering consists of

expenditures for contracts to provide applications and/or systems development support, such as applications systems design, analysis and/or programming services and contracts for the design and development of services, networks or facilities. Military and civilian compensation for software is captured under Personnel. (U.S. Office of Management and Budget, Circular No. A-11, 1990)

A 1988 report by the Institute for Defense Analysis (IDA) for the DOD, (IDA Paper P-2136, 1988) tries to break out software expenditures. From the software expenditure portion of personnel compensation, IDA estimated that approximately 60 percent of personnel compensation goes toward development of new application software. Approximately 40 percent goes for maintenance and enhancement of existing application software. However, it is difficult to substantiate these percentages as the information for this report was accomplished through interviews only.

The report further states that combining the average efforts (personnel compensation and outside contracting costs) for development and maintenance, yields a ratio of 30 percent development to 70 percent maintenance. Additionally, of the total dollars spent annually on AIS software personnel, approximately 71 percent goes for in-house personnel and 29 percent goes for contractor effort (17 percent of AIS developed by contractor, 10 percent maintained by development contractor, and 2 percent maintained by other contractor).

IDA breaks the Exhibit 43A into four categories. They are: software (which includes maintenance programming), hardware, operations (which includes operator costs of running the hardware), and management overhead (which includes the cost of project management). IDA estimates the Operations and Maintenance category is divided equally between software and hardware, while personnel compensation is divided into 60 percent to software, and 20 percent to both operations and management overhead. Although IDA's percentage estimates are of uncertain reliability (based on partial survey), we have been unable to find an alternative source that is more accurate. The IDA report percentages are the best the DOD has (Beyer, telephone conversation, December, 1990).

Table 9 is based on the Fiscal Years 1992 - 1993 Exhibit 43A that the Secretary of Defense reported to OMB. For this study, 1990 figures have been extracted, and by applying IDA's percentages, the results are presented in the table. A copy of the Exhibit 43A and IDA's percentage breakdown are in Appendix B. The Exhibit 43A in Appendix B shows a 1990 total of $8.3 billion rather than $8.7 billion shown in Table 9. This is because the exhibit total includes inter-agency and intra-agency transfers of $357 million.

TABLE 9 FY 1990 REPORT ON INFORMATION TECHNOLOGY RESOURCES DEPARTMENT OF DEFENSE (in thousands)

Categories	Software	Hardware	Operations	Mngt Overhead
Capital Investment:				
Purchase	273,874	1,138,748		
Site, Facility			43,168	
Personnel:				
Pay	1,458,690		486,230	486,230
Other Operating Costs:				
Lease	46,830	55,840		
Space			24,272	
Supplies	340,876			
Commercial Services:				
ADPE Time		45,967		
Voice Comm		1,116,315		
Data Comm		757,289		
Operations and Maint	802,863.5	802,863.5		
Systems Analysis & Design, Programming Engineering	665,637			
Studies	139,539			
Use of Technology	20,671.5	20,671.5		
Total:	3,748,981	3,937,694	553,670	486,230

Source: DOD's 1990 Exhibit 43A and IDA Paper P-2136

The percentages shown in Figure 7 represent the breakdown of 1990 information technology resources from Table 9. In

1990, 43 percent of the budget was allocated for software, while 45 percent was allocated for hardware expenditures. Operations and management overhead were allocated six percent each.

INFORMATION TECHNOLOGY RESOURCES FOR THE DOD IN 1990

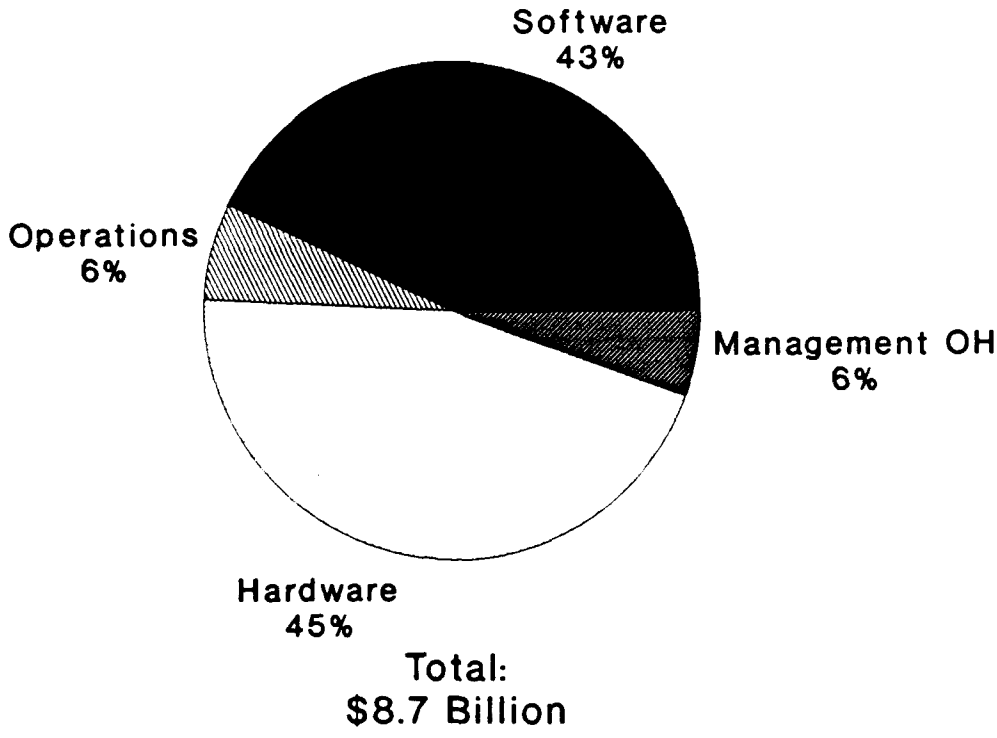


FIGURE 7

The DOD categorizes information technology resources (hardware and software) into major and non-major AIS's. Major systems are systems with a $100 million total investment cost, $25 million in a single year, or special interest designations. Non-major AIS's are systems in excess of $2 million in a fiscal year and fall below the major AIS threshold. Table 10 shows the allocation of the 1990 information technology budget by category. Of $8.7 billion, $2 billion was budgeted for modernization: $829 million for major AIS's, $159 million for non-major systems, and $1,021 million for other miscellaneous modernization which includes in-house development. The other three-fourths of the budget, $6.8 billion was allocated for operations. Operations include fixed costs for systems where no further expansion and no changes were needed. Systems that need error correction, and software perfective maintenance, and adaptive maintenance figures are collected under operations also. (Beyer, telephone conversation, March, 1991)

TABLE 10 INFORMATION TECHNOLOGY RESOURCE SPENDING BY CATEGORY FISCAL YEAR 1990 (in thousands)

Categories	Allocation	Percentage
Modernization	**2,009,779***	**23.03**
Modernization - Major AIS's	829,025	9.5
Modernization - Non-Major AIS's	159,696	1.83
Modernization - Miscellaneous	1,021,009	11.7
Operations	**6,716,796**	**76.97**
Total	8,726,575	100%

Source: DOD Exhibit 43A for Modernization and Operations
* Minor variations in totals are due to rounding practices.

Table 11 breaks out the $3.7 billion software expenditures into modernization and operations. In 1990, approximately $1 billion was budgeted for software modernization and $2.7 billion was budgeted for software operations. Of the $2.7 billion, approximately $600 million was spent on the purchase and lease of software while approximately $2 billion was spent on personnel compensation and contracts for writing software.

TABLE 11 FY 1990 REPORT ON SOFTWARE RESOURCES MODERNIZATION AND OPERATIONS DEPARTMENT OF DEFENSE (in thousands)

Categories	Modernization	Operations	Total
Capital Investment:			
Purchase	219,171	54,703	273,874
Personnel:			
Pay	134,393	1,324,297	1,458,690
Other Operating Costs:			
Lease	1,355	45,475	46,830
Supplies	37,865	303,011	340,876
Commercial Services:			
Operations and Maint	51,748	751,116	802,864
Systems Analysis & Design, Programming Engineering	552,275	113,362	665,637
Studies	74,563	64,976	139,539
Use of Technology		41,343	41,343
Total:	1,071,370	2,698,283	3,769,653

Source: DOD's Exhibit 43A for Operations and Modernization

Figure 8 shows that in 1990, 72 percent of the software budget was allocated to operations to fix existing systems and for corrective and perfective maintenance. The remaining 28 percent was allocated to improve the capability or performance of existing systems and for new system development.

SOFTWARE RESOURCES FOR THE DOD IN 1990

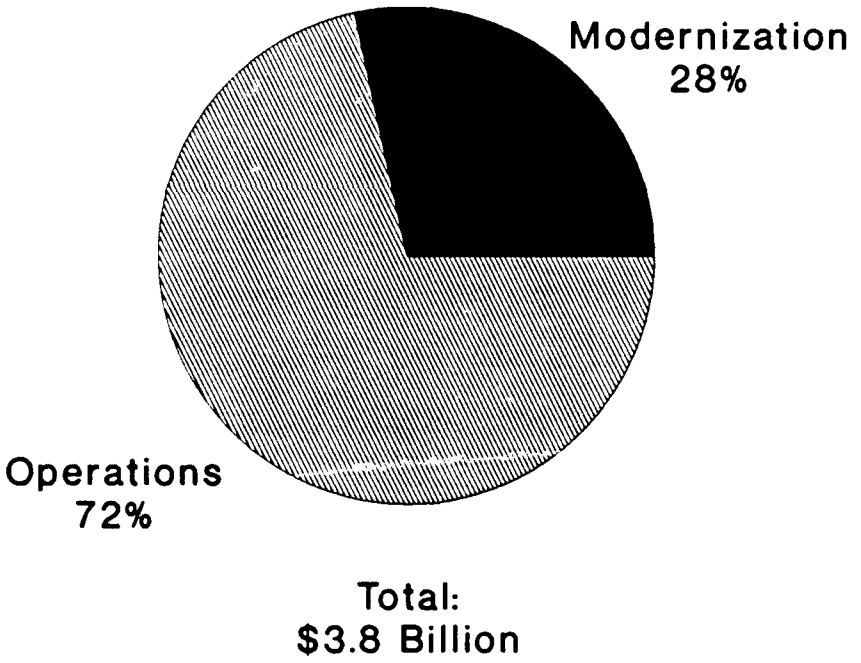


FIGURE 8

C. EMBEDDED SOFTWARE

This second category is a key source of expenditures for software development and maintenance in the DOD - the cost of "embedded" software in weapon systems. "Embedded computer resources" is a widely used term, though it is not well defined. DOD officials differ in their definitions. For the purpose of this study, U.S. General Accounting Office's (GAO) definition will be used (U.S. General Accounting Office, 1990): "Embedded computer resources includes any computer hardware, software or firmware that is physically part of and necessary for a weapons system to perform its full mission." Of these resources, software is usually the most difficult and costly to develop and maintain. GAO reports that cost estimates are not available for all embedded computer resources. Additionally, they found that data on the costs are not routinely collected and available because the work breakdown structure and cost accounting are not set up in such a way to identify them.

Embedded software is used to perform complicated integrated tasks and faces performance and resource utilization constraints far more severe than AIS's. This includes software used for command and control, intelligence, weapons systems and cryptography.

A 1984 study by the National Security Industrial Association (an organization that publishes defense information) estimated that in 1980, the DOD spent about $2

billion for embedded software. Based on budget trends since that time, by 1990, that figure was estimated to rise to $20 to $23 billion. (Zraket, et al. 1990)

The software portion of weapon systems is not reported separately and estimations of embedded software costs must be based on surveys of current weapon systems. We have two such surveys. The Electronic Industries Association (EIA) conducted their survey in 1985 (EIA, 1985). EIA predicted a 12 percent annual growth rate from embedded software costs of $11.4 billion in 1985 to $36 billion in 1995. This means in 1990 approximately $20 billion was spent. The 1990 Mitre Corporation study (Zraket, et al. 1990) yields an estimate of $23 billion (based on $18 billion in 1988 and a 12 percent per year growth rate). Note that these estimates together with the AIS estimate gives a lower DOD total than the $30 billion per year figure which is generally cited. For this study, $23 billion is used as it is the only estimate of embedded software expenditures that has been specifically identified. Other studies combine embedded software expenditures into their software expenditure estimates.

D. TRENDS

As anticipated, both hardware and software expenditures for the U.S. government continue to grow. In fiscal year 1991, $8.7 billion has been budgeted for DOD information technology systems. This is a small increase over the 1990 budget and represents 42 percent of the total federal IT

spending for fiscal year 1991. For budget year 1992, the figure jumps to $9.5 billion and stays at that dollar figure for budget year 1993. (U.S. Department of Defense, Exhibit 43A, 1991)

The total federal information technology spending (hardware and software combined) is estimated to increase 10 percent to $20.5 billion during fiscal year 1991 and projected to jump to $23.5 billion in 1992 (Brewin, page 24, *Federal Computer Week*, April 29, 1991). "Information technology projects generally are not targeted for budget cuts, states Robert Veeder, acting chief of the OMB's information policy branch. Instead, procurement slowdowns will be more likely than terminations" (Mercier, 1991).

A significant element in projected expenditures is reflected in the CIM initiative (Corporate Information Management). The figures shown above for IT spending were cut in 1990 to provide for a plan to eliminate duplicate systems in functions such as payroll, personnel and logistics. CIM is the only DOD system on the Presidential Priority List this year, which is an indication of a widely recognized need to analyze the costs involved in having these duplicate systems. DOD information technology programs will receive significant increases in funding in the proposed 1992 budget, with CIM funding jumping to $219 million from $129 million in 1991 (Brewin, page 4, *Federal Computer Week*, April 29, 1991).

Embedded computer resources are playing a larger and more significant role in the functioning of weapons systems. It is conceivable that virtually every subsystem in all major weapons systems will be computer-controlled.

In 1990, 250,000 computers were installed in military systems, compared with 10,000 in 1980. One illustration of weapons systems' growing reliance on embedded computers and software is the F-16A fighter aircraft built in 1977, which had about 125,000 lines of code and 50 processors. In contrast, the later model F-16C has an estimated 230,000 lines of code and 300 processors. (U.S. General Accounting Office, 1990)

The size and complexity of embedded military software have been growing exponentially, because designers choose to implement much of the increased functional complexity of ground, sea, air, and space systems in **software**. Often there is no alternative. However, it is difficult to accurately project specific costs for developing these programs, due to unexpected problems with poor quality and unreliable systems, as well as inordinately long development times, development cost overruns, and unmaintainable software. (Zraket, et al. 1990)

Data on the cost and size of software, in general, is not routinely collected and available. However, illustrations of program costs that can be documented are as follows:

- The Advanced Tactical Fighter, will require an estimated 4.5 to 6 million lines of code. Additionally, the projected development cost for just the aircraft's avionics embedded computer resources is about **$1 billion**, or about 13 percent of the total weapons system's development cost.
- The B-1B is estimated to have 1.3 million lines of code and the development costs of these computer resources is estimated at $726 million, or about 19 percent of the total weapons system's development cost.
- The Navy's submarines rely on the AN/BSY-2 combat system. It has approximately 200 separate processors having an estimated 193,000 lines of code. The development cost of these computer resources is estimated at $450 million, or about 13 percent of the total weapons system's development cost. (U.S. General Accounting Office, 1990)

In the past, the DOD has not been required to track software expenditures. Recently, DOD Instruction 5000.2, Acquisition of Defense Systems, has been changed to require software expenditures be traceable to a specific weapon or system. In the mean time these expenditures will not be readily available. (Batz, telephone conversation, 1991)

V. WORLDWIDE

A. INTRODUCTION

In 1990, the world information technology industry market was approximately $736 billion of which $357 billion is projected for computers, and related hardware and $185 billion estimated for software and services.

Historically, it has been a good rule of thumb that the U.S. accounts for about 50 percent of the world software but in fact, this share has been shrinking. In 1990 the U.S. accounted for 48.7 percent. Both Europe and Japan have been increasing their software production which is slowly decreasing the U.S. share (Sayadian, 1990).

In the overall information technology industry in 1990, Europe accounted for 30 percent of the world's spending on information technology, second only to the U.S. (45 percent), and well ahead of Japan (9 percent).

In identifying world sources of revenues, world figures are obtained from one government agency, two reports from a private research corporation and computer industry periodicals.

B. ESTIMATED EXPENDITURES

Table 12 identifies world software and services market revenues which include general purpose and embedded software

for North America, Europe, Asia and the Rest of the World. In 1990, the U.S. accounts for 91.4 percent of North America. Canada and Mexico share the remaining 8.6 percent. Europe's figures excludes the Eastern Bloc and Japan is 70 percent of Asia. The Rest of the World is assumed to consist of South America, Africa, and Australia. (Sayadian, 1990)

These worldwide figures (Sayadian, 1990) include processing services for which this study does not consider as software expenditures. Estimates for U.S. software expenditures were obtained by subtracting processing services and adding in-house expenditures. We do not have the data to do this directly, however, we noted that for the U.S., the two figures balanced almost exactly. Therefore, assuming the rest of the world's software market industry to be structured like the U.S., we use Table 12 as our best estimate. If other countries lag behind the U.S. in development, they may be expected to have a larger proportion of in-house expenditures as the U.S. did in previous years.

TABLE 12 WORLD SOFTWARE AND SERVICES MARKET REVENUES
(in billions)

Year	North America	Europe	Asia	Rest of World	Total World
1986	49.1	30.5	15.1	3.9	98.6
1987	58.4	35.4	17.3	4.0	115.1
1988	69.5	41.1	20.2	4.6	135.4
1989	82.7	47.7	22.9	5.0	158.3
1990[E]	98.4	55.3	25.8	5.4	184.9

Source: Computer and Business Equipment Manufacturers Association
Average Annual Compound Growth Rate
86-90(%) 14.2 14.4 17.3 12.0 14.6
[E] - Estimate

Figure 9 shows that in 1990, North America, which includes the U.S., Canada, and Mexico, share the largest percentage of 53 percent of the software and services revenue. Europe's share is 30 percent, followed by Asia with 14 percent, and the rest of the world has 3 percent.

WORLD SOFTWARE AND SERVICES REVENUE FOR 1990 (in billions)

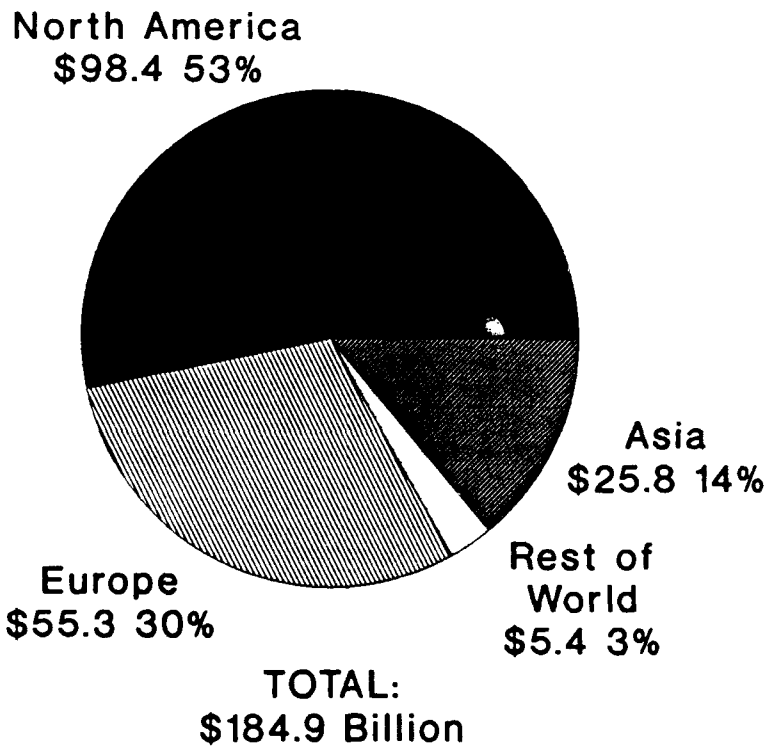


FIGURE 9

According to the *Computer Industry Almanac*, Table 13 shows West Germany's software revenues in 1990 were $4.1 billion, while the United Kingdom's were $5.9 billion. France and Italy had the largest European revenues of $7.1 billion and $6.2 billion, respectively. Japan estimated revenues of $13.1 billion for custom software and $1.7 billion for packaged software, for a total of $14.8 billion. (Juliussen and Juliussen, 1990)

TABLE 13 INDIVIDUAL FOREIGN COUNTRIES 1990 SOFTWARE REVENUES (in billions)

Country	Software Revenues
West Germany	4.1
United Kingdom	5.9
France	7.1
Italy	6.2
Japan	14.8

Source: Juliussen and Juliussen, 1990

C. INTERNATIONAL DATA CORPORATION

International Data Corporation is widely known for its research into global information technology spending in 30 countries. On a worldwide basis, IDC tracks general-purpose computer hardware, packaged and custom software, data communications equipment, hardware maintenance and professional services. (Moschella, 1989)

IDC chooses not to track many other areas such as data processing staff expenditures; telecommunications; products such as automated teller machines and point-of-sale equipment; and the value added provided by processing services companies and value-added resellers. IDC focuses on the general-purpose environments that they have historically tracked.

Because of IDC's access to and familiarity with a variety of outside sources, IDC feels they can pass along rough estimates of the remaining components of the industry that they consider part of the overall information marketplace. It is their belief that for this latter task, high degrees of precision and detail are not essential for most customers' purposes.

The major reason IDC figures were not used in Table 12 is that IDC uses its own standard definitions and exclude many software related expenditures and services so that the figures presented do not meet the criterion for this study. For example, although U.S. research in support services properly includes software support, for the purpose of their report, support services were restricted to hardware maintenance. This exclusion was initiated in order to avoid double-counting with the software category. (Bellomy, 1990)

In IDC's report (Bellomy, October, 1990), Europe refers to the 13 Western European countries traditionally tracked by IDC. In the figures reported for 1990, West Germany did not include any East German expenditures. The Rest of the World

consists of 121 reporting countries in World Bank reports. Eastern European states (Poland, Hungary, and Yugoslavia) reported data to the World Bank, but not others; also missing was the Soviet Union.

IDC assumes that the 30 countries studied represent 98 percent of the world market. The remaining two percent is distributed in hardware and software/services market categories for the Rest of the World. (Bellomy, August, 1990)

Table 14 represents IDC's figures for worldwide packaged software and professional services. Only the U.S., Japan's and the Rest of the World's professional services figures are accurate. Europe's figure has been estimated since the IDC report (Bellomy, October, 1990) did not provide the figure. The figures provided in Table 14 are provided for information only.

TABLE 14 WORLDWIDE SOFTWARE AND SERVICES MARKET - 1990
(in millions)

	U.S.	Europe	Japan	ROW	Total
Packaged Software	18,020	17,321	3,901	3,787	43,030
Professional Services	5,960	5,058	6,205	474	17,697
Total	23,980	22,379	10,106	4,261	60,726

Source: International Data Corporation, 1990

D. TRENDS

IDC's 1990 survey shows that, while Western Europe, Japan, and the U.S. accounted for only 15 percent of the world's population, they still represented 90 percent of worldwide IT spending (hardware and software included) in 1989 (Bellomy, 1990). This trend is projected to continue. Worldwide IT spending as a whole is growing about as fast as the U.S. If this trend continues, it should tripple by the year 2000 with the fastest growth in Asia.

IDC has made some IT projections through 1994. IDC projects that Western European growth should fall between the rates for the U.S. and Japan, and that should suffice to bring it even with the U.S. as an overall IT market by 1994. The rest of the world was estimated to represent ten percent of the world IT market in 1989, and is projected to rise to 11 percent in 1994. (Bellomy, October, 1990)

IDC also estimated that in 1990 the U.S. 15.5 percent of IT spending goes for packaged software, compared with well under seven percent for Japan. However, Japan spends 28 percent of its total professional services, mostly custom software compared with 16 percent for the U.S. (Bellomy, October, 1990)

Although the U.S. software industry continued to lead the world in technology and sales in 1989, competition from foreign software suppliers increased. Because of the

strategic and economic potential of new software, many foreign countries focused on developing their software industries. The 1990 annual *Datamation* report states the outlook for the information systems industry is very positive. Worldwide demand for computer hardware, software, networking and services is at record level. Users identify information systems as the most important factor of production for their enterprises in the 1990s. (Kelly, 1990)

"The U.S. leads in computers, software and services, and in some areas of industrial automation," says the president of the European Association of Manufacturers of Business Machines and Information Technology. "Japan leads in components, consumer electronics and some office products, while Europe is third except in telecommunications and software and services." (Barnat, 1990)

The president of IDC Japan Ltd. expects overall IT purchases in Japan to grow about 12 percent in 1990, with hardware-only revenues up 13 percent, and software-only revenues up 15 percent. Systems integration will be the largest mover, growing at more than 30 percent by 1992. (Johnston, 1990)

VI. FURTHER RESEARCH

The problem in determining software expenditures is threefold. It is very costly and time consuming to collect the data. There are no industry standards for collecting the data. And there is no regulation requiring the data to be collected. Hence, private research firms seize the opportunity to conduct surveys and market the information.

A limiting factor was the lack of precise software definitions and classifications. There are no consistent definitions of software and types of software. This makes it difficult to correlate statistics from different sources because of different methods of classifying software. Software then, is often not counted and reported, or the expenditures are combined with other related expenditures, for instance, hardware. In addition to this, there are no firm criteria for determining the numbers to include for associated industries. For example, a good part of the telecommunications industry consists of software.

Further research to determine industry-wide definitions could be useful to decrease the time-consuming and costly expense of gathering software costs. Furthermore, if this data could be captured quickly and reliably it could eliminate much of the redundancy and double counting of industry statistics. Once consistent definitions are in place,

research could be conducted to develop a cost effective system to accurately collect and then develop standard methodologies to analyze the data.

There are two ways to assess the size of the industry: through revenues earned by the various industry components, and through employment statistics. But to obtain the in-house software development expenditures, an estimation technique had to be used to determine these expenditures. In-house expenditures were estimated using a labor dollar estimate and labor statistics. The annual cost per programmer was also estimated to help identify internal software development expenditures.

This approach was used to estimate worldwide in-house development without verifying that other countries have a similar market structure and the figures given should be taken cautiously. The 37.9 percent deduction across the board for the U.S. processing services may have been accurate, however, the same percentage was used for the world without verification.

This study revealed that there is no mechanism for reporting what proportion of a products cost represents embedded software. DOD and other government agencies are working together to improve software development practices and to track the cost of development. Tracking embedded software expenditures has not been required until just recently and the transition to trace these costs is underway.

Recommendations for further research, from a very broad perspective, would be to analyze and determine the cost effectivness of an industry-wide on-line system to reduce the time and cost of gathering software expenditures. Definitions and classifications of software expenditures would have to be acceptable and approved. This system should provide a single source of current information and include capturing embedded and in-house expenditures.

Further research into validating the estimation technique used to determine in-house expenditures for the U.S. and worldwide is recommended. This includes the validation of the annual cost per programmer and labor dollar estimates used to estimate internal software development expenditures. Further research into DOD's new policy to track and report embedded software costs and its implementation would be useful to validate the embedded software expenditures.

VII. CONCLUSIONS

Though accurate figures cannot be obtained for the U.S., DOD, and the world, the following figures for 1990 are reasonable. The U.S. software expenditures is approximately $90 billion, while the DOD is spending about $4 billion for administrative information technology systems, and spends approximately $23 billion on embedded software. Worldwide software expenditures are approximately $185 billion.

The most important lesson learned was that there was no way to account for software development and maintenance costs directly. Obtaining reliable statistics for the software industry was difficult because:

- There are no consistent definitions or methods of classifying/grouping software.
- Many software costs are hidden (lumped with hardware and services, or excluded from budgeting reports). For example, high costs are associated with large weapon system programs that rely increasingly on embedded software, figures exclude internal development expenditures.
- There has been a tremendous proliferation of software use throughout business and government, with a corresponding proliferation of software activities and consultants. Many of these are small, private

proprietorships that are not counted in company survey statistics.

A wide variety of figures have been published inconsistently and without industry standards. There is a broad general agreement on trends, however, some sources give widely differing values since they're using different definitions of what is included in total software expenditures.

The trends imply software expenditures are projected to continue their growth, though at this time the U.S. share is decreasing slightly as foreign competition is strengthening its position. The DOD is consolidating its major systems to try to decrease some of its software costs, however, an increase of complex software is continuously being developed for embedded systems.

High growth has been the norm in the software industry. Now that the industry is maturing and settling down to normal growth rates, the analysts call it the "computer slump." The growth rate of the computer industry has slowed due to its sheer size. However, software and services continues to record the fastest growth of the four computer and business equipment industry sectors.

The software industry is expected to continue to grow as the information technology industry is one of the primary areas for capital purchases to increase labor productivity. A shortage of entry level office workers and data processing

personnel may lead to increased automation in factories and offices. Also, continuing advances in technology, declining costs and consumer education is expected to promote automation and maintain the high rates of real growth experienced in the past.

APPENDIX A SOURCES

1. U.S. Office of Management and Budget

A joint effort by the Office of Management and Budget, the General Services Administration's Information Resources Management Service, and the National Computer Systems Laboratory of the Department of Commerce's National Institute of Standards and Technology publishes *A Five-Year Plan for Meeting the Automatic Data Processing and Telecommunications Needs of the Federal Government* (U.S. Office of Management and Budget, 1990). This 186-page annual r ort represents information technology system activities and Exhibit 43A expenditures of the Federal government for fiscal years 1989 through 1991.

The Five-Year Plan provides an analysis of Federal obligations for information technology resources contained in the Budget of the United States Government for Fiscal Year 1991. The term information technology resources encompasses computer and telecommunications hardware, software and services, but excludes the following categories:

- Obligations for software embedded in combat weapon systems;
- Activities funded by Federal grants;
- Activities classified for national security purposes;
- Analog computers;

- Certain telecommunications facilities exempted by the General Services Administration.

The analysis consolidates Exhibit 43A data supplied by executive branch agencies in response to the Office of Management and Budget requirement (OMB Circular No. A-11, Preparation and Submission of Budget Estimates, Section 43, Data on Acquisition, Operation, and Use of Information Technology Systems).

2. The Mitre Corporation

In a prepublication edition of "Software as a Dual-Use Technology," Charles A. Zraket, former President of MITRE Corporation, presents an extensive overview of software expenditures in relation to both the software industry, and software usage throughout the private sector and DOD. Zraket's 38-page study, prepared for the DOD, is lent credence by his position as former head of one of the nation's largest firms conducting research for the U.S. government and private industry.

3. U.S. Government Accounting Office

Significant military expenditures are incurred in developing systems yet these expenditures are virtually untraceable. We can only guess from the "estimates" provided to get an idea of how big the costs really are.

The work on this GAO report was conducted from June 1989 through December 1989, primarily at the Secretary of Defense offices in Washington, D.C., and at selected weapons system

program offices throughout the country. Interviews of knowledgeable OSD and service program officials and reviews of recent publications and reports substantiated the importance and prevalence of embedded computer resources. Nine weapons system programs were analyzed to determine the amount of computer resources being incorporated in each, and the cost to develop the entire weapon system.

4. The Computer Industry Almanac 1991

The Computer Industry Almanac 1991 is a computer industry reference specializing in identifying forecasts, trends and sales estimates. It focuses on companies, products, and trends of the industry. The publication is in its third year, has wide public distribution, and is approximately 600 pages. The software segment is limited to gathering system software and application software revenues by commercial software firms. These firms' software development and maintenance expenditures are often grouped under the heading Professional Services and are not identified individually. Professional services consist of data processing consulting, system design, development, custom software, maintenance and disaster recovery.

5. U.S. Department of Commerce

The U.S. Department of Commerce, Office of Computers and Business Equipment, dedicates a chapter to computer equipment and software in the *U.S. Industrial Outlook* each year. The chapter provides trends and forecasts for computers,

peripherals and software. Projections for each segment during the current year and long term prospects are given. Industry growth data and industry employment levels can be found. Development of foreign involvement in the computer industry is tracked in each area.

6. Datamation

Datamation is a bimonthly magazine for managers of information technology that provide comprehensive articles and surveys, illustrated in detail with charts and graphs, directed at the professional. This publication is extensively quoted by the U.S. Department of Commerce and other periodicals, to include some research firms. Sources include U.S. and worldwide industry surveys. For example, these periodicals provide specific U.S. and worldwide trends highlighting Europe's advantage in software and services in Europe and Japan's move away from the hardware push into system integration.

7. Computers and Business Equipment Manufacturers Association

CBEMA is a trade association of manufacturers, assemblers and producers of information processing, business and communication products, supplies and services. CBEMA monitors domestic and international issues that affect this industry. CBEMA's member companies encompass about half of the information technology industry's revenues. In this report, *The Information Technology Industry Data Book, 1960-*

2000, expands the Association's statistical program which began in the 1940's. In this report CBEMA has analyzed hardware and software expenditures and forecasts economic trends and domestic demand through the year 2000.

8. International Data Corporation

Two IDC reports - *How Big Is the Information Industry? And How Fast Can It Grow?* 1989 by David Moschella, *Global IT Market Trends, 1990* by Charles Bellomy were used to support world revenues and projections.

These reports are used by industry analysts, U.S. Department of Commerce, and frequently quoted by other research firms. These reports are monthly bulletins that extrapolate information from the worldwide survey. IDC conducts worldwide surveys and includes the results in its *Worldwide Information Technology Spending Patterns, 1989-1994: An Analysis of Opportunities in 30 Countries*. The report can be purchased for $15,000.

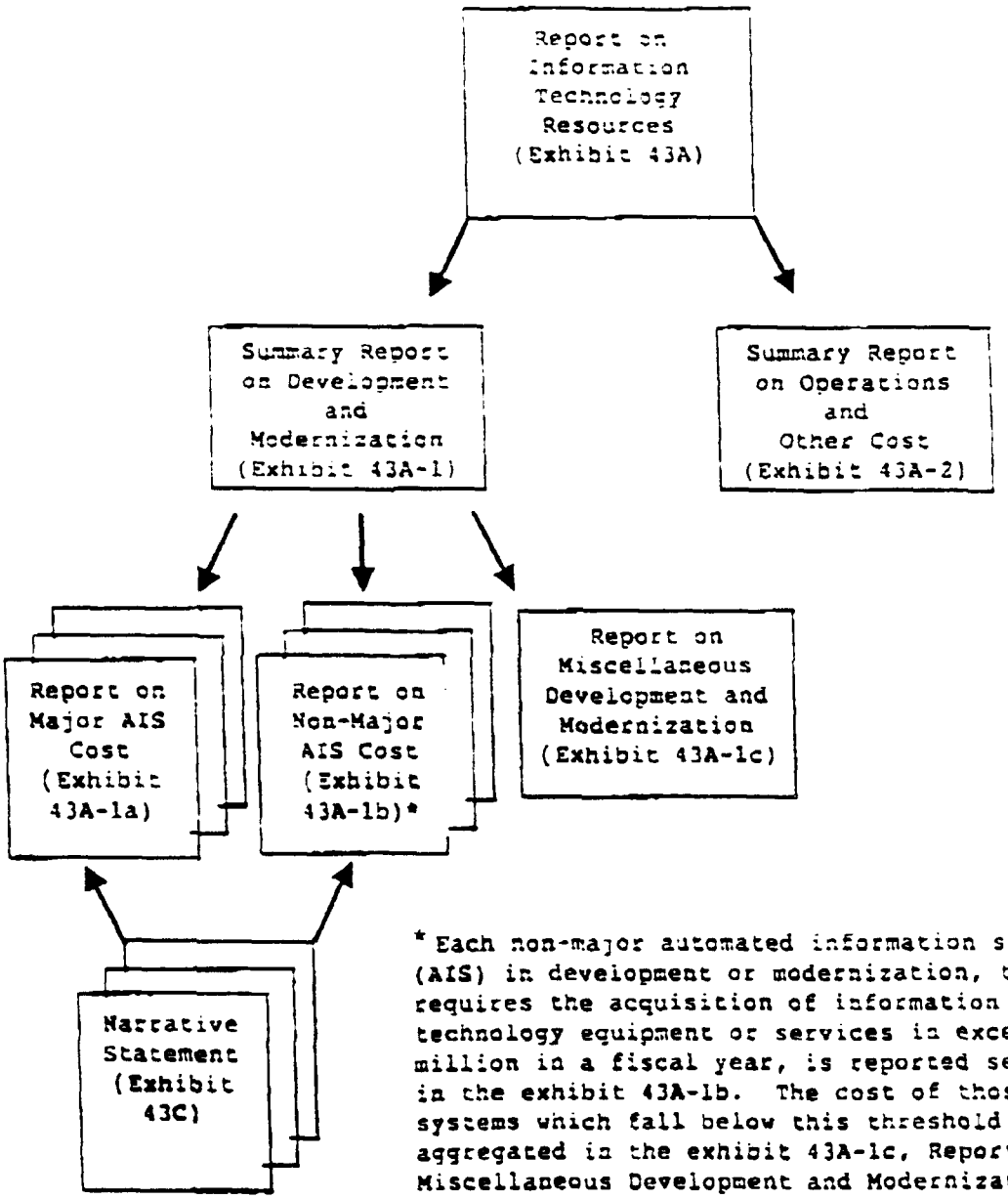
IDC maintains an online database that records information on a large number of installations, representing over 80 percent of the general purpose computers installed in the U.S. This database has provided them with an ability to monitor computing trends in user organizations.

APPENDIX B DOD'S EXHIBIT 43A

The DOD's Fiscal Years 1992 and 1993 Exhibit 43A for information technology resources to include the breakdown for modernization and operations is provided. Fiscal year 1990 figures are included. These exhibits provide the opportunity to see what is being budgeted for the next couple of years. Additionally, an explanation of the series 43 exhibits definitions for modernization and operations is given. For informational purposes, the Fiscal Year 1992 Information Technology Spending by Category is provided.

In Chapter III, the author used percentages given by IDA, in their Paper P-2136, to distinguish hardware and software expenditures. A copy of the DOD software AIS expenses for fiscal year 1987 and the respective breakdowns and the percentages are provided.

To improve the justification book material for information technology systems, DoD modified the series 43 exhibits, as shown below, to separate the cost of modernization efforts from ongoing operations.



* Each non-major automated information system (AIS) in development or modernization, that requires the acquisition of information technology equipment or services in excess of $2 million in a fiscal year, is reported separately in the exhibit 43A-1b. The cost of those systems which fall below this threshold are aggregated in the exhibit 43A-1c, Report on Miscellaneous Development and Modernization.

Modernization encompasses new AISs that are planned or under development and any change or modification to an existing AIS which results in improved capability or performance of the AIS. Operations represents the cost of exisitng AISs, as currently configured, without further changes or expansion of existing capabilities to new users.

Fiscal Years 1992 and 1993
Report on Information Technology Resources
Department of Defense
(in thousands of dollars)

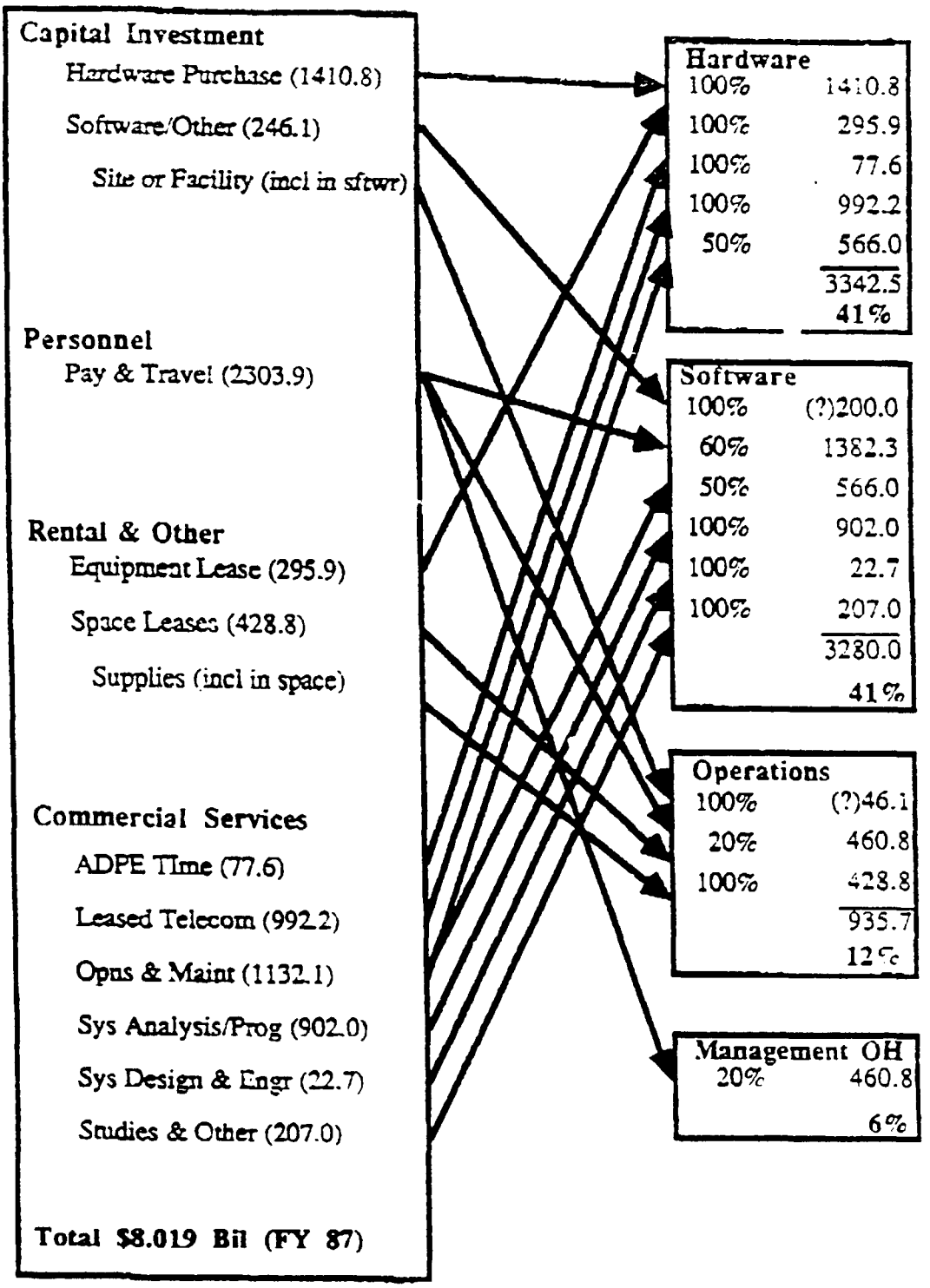
	FY 1990	FY 1991	FY 1992	FY 1993
1. Capital investments				
A. Purchase of hardware	1,138,748	1,044,290	1,476,218	1,576,466
B. Purchase of software	273,874	235,923	259,183	216,977
C. Site or facility	43,168	51,984	45,390	50,761
Subtotal	1,455,790	1,332,197	1,780,791	1,844,204
2. Personnel				
A. Compensation, benefits and travel	2,431,150	2,553,693	2,626,780	2,654,794
B. Workyears	(66,126)	(65,603)	(64,559)	(63,074)
Subtotal	2,431,150	2,553,693	2,626,780	2,654,794
3. Equipment rental, space, and other operating costs				
A. Lease of hardware	55,840	52,785	46,775	46,338
B. Lease of software	46,830	52,633	53,710	57,056
C. Space	24,272	25,579	29,182	28,792
D. Supplies and other	340,876	386,068	403,245	403,898
Subtotal	467,818	517,065	532,912	536,084
4. Commercial services				
A. ADPE time	45,967	43,884	33,940	37,330
B. Voice communications	1,116,315	1,201,053	1,208,178	1,192,247
C. Data communications	757,289	778,304	780,325	784,438
D. Operations and maintenance	1,605,727	1,708,541	1,894,883	1,807,675
E. Systems analysis, programming, design, and engineering	665,637	802,324	829,817	864,909
F. Studies and other	139,539	140,170	145,699	147,086
G. Significant use of information technology	41,343	33,935	33,904	34,808
Subtotal	4,371,817	4,708,211	4,926,746	4,868,493
5. Interagency services				
A. Payments	1,002,492	1,086,359	1,077,002	1,058,303
B. Offsetting collections	(1,300,197)	(1,407,592)	(1,352,183)	(1,367,537)
Subtotal	(297,705)	(321,233)	(275,181)	(309,234)
6. Intra-agency services				
A. Payments	372,446	420,196	650,299	617,509
B. Offsetting collections	(372,446)	(420,196)	(650,299)	(617,509)
Subtotal	0	0	0	0
7. Other services				
A. Payments	9,593	17,493	18,494	15,269
B. Offsetting collections	(69,213)	(64,836)	(67,664)	(72,441)
Subtotal	(59,620)	(47,343)	(49,170)	(57,172)
Total	8,369,250	8,742,590	9,542,878	9,537,169

Fiscal Years 1992 and 1993
Information Technology Resources - Modernization
Department of Defense
(in thousands of dollars)

	FY 1990	FY 1991	FY 1992	FY 1993
1. Capital investments				
A. Purchase of hardware	763,907	758,378	1,143,049	1,253,903
B. Purchase of software	219,171	186,978	226,500	182,957
C. Site or facility	17,521	26,593	29,649	38,400
Subtotal	1,000,599	971,949	1,399,198	1,475,260
2. Personnel				
A. Compensation, benefits and travel	223,989	230,632	241,303	248,519
B. Workyears	(5,203)	(4,873)	(4,709)	(4,495)
Subtotal	223,989	230,632	241,303	248,519
3. Equipment rental, space, and other operating costs				
A. Lease of hardware	6,811	6,294	4,335	3,301
B. Lease of software	1,355	1,369	1,504	1,820
C. Space	286	1,801	2,315	2,823
D. Supplies and other	37,865	39,506	43,095	44,193
Subtotal	46,317	48,970	51,249	52,137
4. Commercial services				
A. ADPE time	3,769	767	687	714
B. Voice communications	10	5	0	0
C. Data communications	4,761	4,926	4,624	4,692
D. Operations and maintenance	103,496	85,925	93,689	88,006
E. Systems analysis, programming, design, and engineering	552,275	695,172	713,080	770,495
F. Studies and other	74,563	64,230	62,807	70,360
G. Significant use of information technology	0	0	0	0
Subtotal	738,874	851,025	874,887	934,327
5. Interagency services				
A. Payments	12,108	17,030	19,236	23,887
B. Offsetting collections	(9,163)	(33,068)	(5,946)	(12,114)
Subtotal	2,945	(16,038)	13,290	11,773
6. Intra-agency services				
A. Payments	29,335	25,532	124,195	114,305
B. Offsetting collections	(29,335)	(25,532)	(124,195)	(114,305)
Subtotal	0	0	0	0
7. Other services				
A. Payments	2,597	9,958	11,363	9,128
B. Offsetting collections	(52,072)	(49,848)	(50,699)	(51,356)
Subtotal	(49,475)	(39,890)	(39,336)	(42,228)
Total	1,963,249	2,046,648	2,540,591	2,679,788

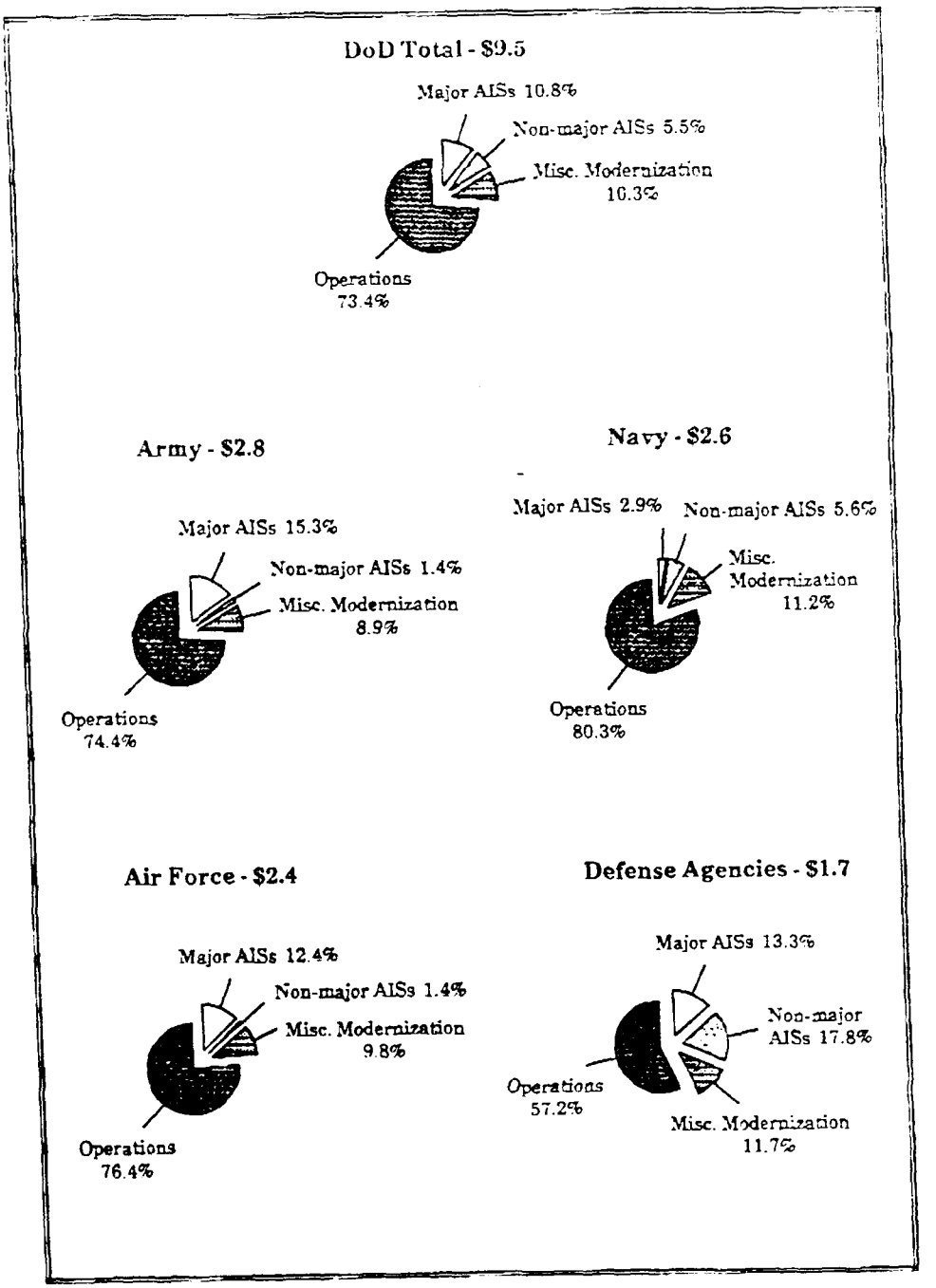
Fiscal Years 1992 and 1993
Information Technology Resources - Operations
Department of Defense
(in thousands of dollars)

	FY 1990	FY 1991	FY 1992	FY 1993
1. Capital investments				
A. Purchase of hardware	374,841	285,912	333,169	322,563
B. Purchase of software	54,703	48,945	32,683	34,020
C. Site or facility	25,647	25,391	15,741	12,361
Subtotal	455,191	360,248	381,593	368,944
2. Personnel				
A. Compensation, benefits and travel	2,207,161	2,323,061	2,385,477	2,406,275
B. Workyears	(60,923)	(60,730)	(59,850)	(58,579)
Subtotal	2,207,161	2,323,061	2,385,477	2,406,275
3. Equipment rental, space, and other operating costs				
A. Lease of hardware	49,029	46,491	42,440	43,037
B. Lease of software	45,475	51,264	52,206	55,236
C. Space	23,986	23,778	26,867	25,969
D. Supplies and other	303,011	346,562	360,150	359,705
Subtotal	421,501	468,095	481,663	483,947
4. Commercial services				
A. ADPE time	42,198	43,117	33,253	36,616
B. Voice communications	1,116,305	1,201,048	1,208,178	1,192,247
C. Data communications	752,528	773,378	775,701	779,746
D. Operations and maintenance	1,502,231	1,622,616	1,801,194	1,719,609
E. Systems analysis, programming, design, and engineering	113,362	107,152	116,737	94,414
F. Studies and other	64,976	75,940	82,892	76,726
G. Significant use of information technology	41,343	33,935	33,904	34,808
Subtotal	3,632,943	3,857,186	4,051,859	3,934,166
5. Interagency services				
A. Payments	990,384	1,069,329	1,057,766	1,034,416
B. Offsetting collections	(1,291,034)	(1,374,524)	(1,346,237)	(1,355,423)
Subtotal	(300,650)	(305,195)	(288,471)	(321,007)
6. Intra-agency services				
A. Payments	343,111	394,664	526,104	503,204
B. Offsetting collections	(343,111)	(394,664)	(526,104)	(503,204)
Subtotal	0	0	0	0
7. Other services				
A. Payments	6,996	7,535	7,131	6,141
B. Offsetting collections	(17,141)	(14,988)	(16,965)	(21,085)
Subtotal	(10,145)	(7,453)	(9,834)	(14,944)
Total	6,406,001	6,695,942	7,002,287	6,857,381



FY87 DoD Software AIS Expenses

Information Technology Spending by Category
Fiscal Year 1992
(in billions of dollars)



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